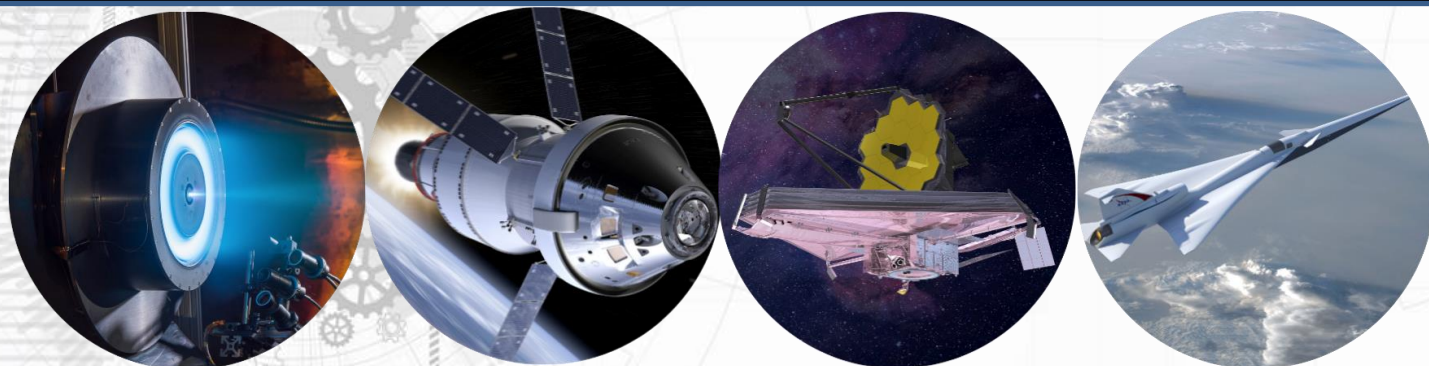


Investment Decision Best Practices for NASA from Venture Capital



Venture Capital Study
NASA Office of the Chief Technologist
Strategic Integration

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Executive Summary

American entrepreneurs, and the investment firms that enable them, represent one of the most innovative and dynamic aspects of the Nation's economy. Startups are agile, resilient, learn quickly; and these successful innovators transform society. Hundreds of billions of dollars controlled by venture capital firms foster and drive these emerging businesses across America. However, a recent report indicated that only three percent of these investment dollars are channeled to aeronautics and space endeavors¹.

The Nation has challenged NASA to fulfill several ambitious goals to meet America's aeronautics, science, and space exploration missions. As NASA's champions of innovation, the Office of the Chief Technologist (OCT), in partnership with the Agency's four mission directorates, performed this study of venture capital (VC) firms. NASA seeks to leverage the interest and insights of the venture capital community to engage additional solution providers to fulfill NASA's technology and commercial space goals. The VC Study team believes that selective lessons from this community could inform and influence NASA's internal research and development activities.

OCT contacted a broad spectrum of VCs to discuss the rationale used when making investment decisions; practices used to support their companies; and to discuss how NASA might encourage investment in space-related businesses.

The VC Study team developed several findings and proposed twelve recommendations to improve the agility of NASA's activities, and to create a foundation for understanding and communication between NASA and the VC community. The study suggests how NASA may learn from the selection process, criteria, and rationale of VC firms, as well as the mentoring and support processes and approaches that turn VC investments into successful companies. The VC Study captures approaches to externally share insights about NASA needs and commercial opportunities, to increase awareness for companies that seek to do business with NASA. The study also proposes increasing market research to provide NASA decision makers an understanding of emerging technologies and new commercial services.

VCs pursue opportunities to seek profit, by investing in the development and growth of successful businesses, while NASA seeks a growing and thriving commercial space sector to provide the products and services needed to support its missions. There is much common ground to consider, and the study authors believe that increasing the depth of dialogue with the VC Community will serve Agency needs.

¹ *Innovation Research Interchange, "2018 R&D Trends Forecast,"*
https://www.iriweb.org/sites/default/files/IRI_TrendsForecase_Vol61.1_v2.pdf

Introduction

Every year, NASA is challenged by the President and Congress to deliver a variety of missions from advancing terrestrial air mobility systems, to improving scientific understanding of Earth's ecosystem, to studying the solar system's outer planets, to learning to live on Earth's moon. To complete these missions, the Agency needs to fully develop critical technologies and infuse new capabilities. NASA must do this while being good stewards of taxpayer money. To this purpose, NASA continuously seeks new methods to meet its goals while staying on budget. There is a broad spectrum of approaches currently used by the Agency. One such method is to "buy" new technologies as commercial products. Alternatively, NASA also engages in internal research and technology development; currently, the Agency is working on more than 1,000 active technology development projects. This study seeks to add additional solution providers and innovations into the pool of ideas available to NASA.

The U.S. private sector, and its commercial markets, drive the most competitive, innovative and productive economy in human history. Through direct investment, VCs enable key industrial sectors. Many NASA technologies have been "spun off" to benefit the American public. To continue to lead American aerospace science and exploration, NASA must learn to adopt additional methods and harness commercial markets to turn innovative technologies into flight ready capabilities with efficiency and speed equal to that of American business.

To reach that goal, NASA's Office of the Chief Technologist looked to VC firms for insight about their best business practices. The main goals of this study are to understand what makes a company an attractive investment for venture capitalists, how venture capitalists foster the growth of their investments, and if VCs see any areas in which NASA and the VC community could collaborate. To meet these goals, four main drivers of this study were developed:

1. To learn how VCs make investment decisions, and how NASA could adopt their methodologies to evaluate R&T proposals
2. To better understand the ongoing support that VCs provide to the Entrepreneurs that receive VC investment
3. To explore how NASA could leverage VCs investment funding to develop and mature technologies that NASA needs
4. To explore how NASA might engage with VCs to further commercialize and spinoff mature NASA technologies

A better understanding of how VCs support startups developing new technology will allow NASA to incorporate new approaches to improve its technology selection and maturation processes as the Agency moves forward in its ambitious schedules to meet scientific, aeronautic, and exploration challenges.

Study Overview

OCT worked with representatives of each NASA mission directorate throughout this study. NASA's mission directorates are particularly interested in understanding venture capitalists' methods and needs to support a variety of NASA activities. Perspectives from each mission directorate and what it hoped to learn from this study include:

Aeronautics Research Mission Directorate (ARMD)

ARMD focuses on innovative research to address the major challenges facing aviation, and to promote global growth in air traffic. NASA's Advanced Air Mobility Mission (AAM) is actively working with the VC community as part of their AAM Ecosystem working groups and overall partnership strategy. Through the NASA Aeronautics Research Institute (NARI), ARMD reaches out to innovators, both traditional and non-traditional, through public collaboration sessions that include entrepreneurs and startups in Silicon Valley. In addition, the Convergent Aeronautics Solutions (CAS) project enables the transition of feasible ideas to industry and within NASA. Current CAS investments are made using a venture capital-inspired approach including an annual pitch competition used to select the next round of studies.

ARMD's interests are related to two of the four main drivers of this study:

- To learn how VCs make investment decisions, and how NASA could adopt their methodologies to evaluate R&T proposals
- To explore how ARMD might engage with VCs to further commercialize and spinoff mature NASA technologies and commercial capabilities

Human Exploration and Operations Mission Directorate (HEOMD)

HEOMD seeks to forge partnerships that foster and capture outside innovation to more affordably achieve its mission and enable NASA to focus on its unique strengths. The mission directorate strongly desires to "buy" new technologies as commercial products and work with industry to attain the necessary exploration capabilities. HEOMD wants to create agility in its engineering and acquisition process to accommodate an accelerating pace of technology development performed outside of NASA. HEOMD is interested in adopting new methods and approaches to engage more U.S. commercial markets, to continue to lead American exploration in the 21st Century.

HEOMD's goals for learning more about venture capitalists fall into two of the four main drivers of this study:

- To explore leveraging VC relationships to develop and mature the technologies and capabilities that NASA needs
- To explore engaging with VCs to further commercialize and spinoff mature NASA technologies, and to help advance commercialization opportunities in Low Earth Orbit

Science Mission Directorate (SMD)

SMD is interested in discovering ways to cooperatively develop scientific technologies that are mutually useful to the government and the private sector. NASA currently funds the development of scientific instruments through government grants, contracts, prizes and challenges. By identifying technologies where commercial and NASA interests overlap, the Agency hopes to attract investments from the private sector, which will allow development of critical new technologies with less financial reliance on government funding.

SMD's interests in the VC community align with two of the four main drivers of this study:

- To explore how NASA could leverage VCs relationships to develop and mature the technologies and capabilities that NASA needs
- To explore how SMD could engage with VCs to further commercialize and spinoff mature NASA technologies and commercial capabilities

Space Technology Mission Directorate (STMD)

STMD invests in technologies across the spectrum of technology readiness levels through a portfolio of programs that stimulate and encourage creativity within NASA, industry and academia. Similarly, the venture capital community collectively invests in many different companies at different stages of development. STMD seeks better understanding of how and why VC firms invest in different technologies and companies. This insight may produce ideas into how the mission directorate might invest more effectively, and improve the successes of those investments.

STMD's goals are directly reflected in two of the four main drivers of this study:

- To learn how VCs make investment decisions, and how NASA could adopt their methodologies to evaluate R&T proposals
- To better understand the ongoing support that VCs provide to the entrepreneurs that receive VC investment

Methodology for VC Discussions

As previously described there are four main drivers of this study:

1. To learn how VCs make investment decisions, and how NASA could adopt their methodologies to evaluate R&T proposals
2. To better understand the ongoing support that VCs provide to the Entrepreneurs that receive VC investment
3. To explore how NASA could leverage VCs investment funding to develop and mature technologies that NASA needs
4. To explore how NASA might engage with VCs to further commercialize and spinoff mature NASA technologies

The study was conducted in three phases: research, interviews, data analysis and recommendations.

PHASE 1: Research

The study team began by gaining a comprehensive understanding of how the Agency has interacted with VCs in the past and how it is working with them now. Descriptions of these VC-related activities are in Appendix B of this report. To understand these interactions, leaders from each of these activities spoke to the study team, describing their programs' work with VCs including what has worked well, what has not, and what could be better in the future.

During this phase the study team also researched VC firms to identify the best targets for interviews. Over 160 VC Firms across the United States were considered for engagement. Selection criteria included location, stage of business or technology development the firm has invested in, and primary investment areas. The team down-selected 25 VC firms to contact for interviews.

The team created detailed firm profiles for the 25 firms selected. The profiles were generated from public data sources and included information on company background, investment philosophy, total investments, primary investment areas, size of investment portfolios, successful exits, and firm leadership. An excerpt from a company profile is shown in figure 1. The study team contacted all firms selected and 13 agreed to participate in the study. Appendix A contains an overview of each of the firms interviewed for this study.

PHASE 2: Interviews

Prior to each interview, the team developed an interview narrative specific to each VC firm. The narratives helped to guide the interview conversation by focusing on firm philosophy and directing discussion toward the goals of the study. Interviews were led by study team lead Greg Clements, but all team members were encouraged to participate and add questions as desired. For each interview two team members recorded detailed notes. The two sets of notes were then combined to create a

500 Startups

<https://500.co/>



Overview

Founded in 2010, Silicon Valley-based 500 Startups is rated the most active venture capital firm. 500 Startups provides seed capital and Seed Accelerator Programs to companies worldwide in a range of industries, mostly actively software related industries. 500 Startups has over \$454M in committed capital, with investments in over 2,400 companies spanning over 75 countries. This portfolio includes 16 unicorns (companies valued over \$1B) as of 2019. The company has teams located in 20 countries around the world to support this global portfolio. 500 Startups has had 223 exits, the most notable including Credit Karma, Twilio, and The RealReal.

Investment Philosophy

500 Startups aims to make many small early-stage investments, resulting in a large diversified portfolio with low risk and high potential return. This focus on bulk differentiates 500 Startups from other VC firms, which traditionally focus on a few high value companies. The company made 75 investments in just its first 6 months operating. 500 Startups also has a global focus that grew over time, as the company continued to hire internationally.

"At 500, we're pretty transparent about our investment thesis. Compared to more traditional VC firms on Sand Hill Road, we prefer a large, diversified portfolio of early-stage investments that reduces risk and maximizes potential return. In other words, we advocate lots of little bets. We're looking for companies that are operational at less than \$1M in external financing." – Bedy Yang, Managing Partner

"With the exception of a handful of other investors, nobody makes more than 50 investments in a year. We are applying a different philosophy and model from most other funds. A lot of people think our model is kind of crazy, but I would actually correct them and say it's really one of the most conservative strategies around. At least relative to size of [the] bet and percentage of capital deploy." – Dave McClure, Founder

"If you look at our early team, our DNA has always been very global with experience growing up abroad or working internationally. So it really comes down to the thing that we always say which is that we always believed from day one that there are brilliant startups all over the world, but opportunity isn't universal." – Tim Chae, General Partner

"Our investment philosophy is lots of little bets. We believe a large, diversified portfolio of seed-stage and early-stage investments reduces risk and maximizes potential return relative to 'traditional' funds... We are the rocket fuel that helps you get to the next level. What is the one

Figure 1. Sample Company Profile – Compiled from publicly available data

comprehensive account of the interview. The final account was analyzed to identify key points that address study drivers. The interview notes were supplied to each firm to ensure the notes correctly captured their perspective, and to supply any additional information they felt would support the study goals. A sample excerpt of final interview notes is shown in figure 2.

SpaceFund
Interview Notes

<https://spacefund.com/>

SpaceFund™

Meeting Information

Date: May 21, 2020

Participants:

Quake Capital: Meagan Crawford

NASA: Greg Clements, Al Conde, Ajay Mysore, Michael Read, Dave Voracek, Ken Wright, Richard Howard, Jonathan Rall, Amanda Hernandez, Husna Aziz, Carrie Mullins

Study goals:

1. To learn how VCs make investment decisions, and how NASA could adopt their methodologies to evaluate R&T proposals
2. To better understand the ongoing support that VCs provide to the Entrepreneurs that they invest in
3. To explore how we could leverage VCs investment (\$\$) to develop and mature technologies/capabilities that NASA needs
4. To explore how we could engage with VCs to commercialize and spinoff mature NASA technologies/capabilities

Selection of Investments

Key Messages

- ❖ If a company fits in one of our sectors of interest, it then must pass three criteria: team, tech, and timing.
- ❖ Once these are all checked, more extensive due diligence is done, such as evaluating financials and building connections with the company's team.
- ❖ SpaceFund encourages government contracts; they create stability during uncertain times.

Intros/Background

Meagan Crawford: My partner has been trying to get space entrepreneurs going for 30 years. Next week's crewed launch is a big deal for us; we're a new operation. We invest exclusively in space and made our first three investments already. We're still fundraising, this is the hardest part of my job. We're excited to pioneer the new world of venture space capital, which is a new thing.

Figure 2. Sample Interview Notes – used in this report with the permission of SpaceFund

PHASE 3: Data Analysis and Recommendations

Once all comprehensive interview packages were completed the study team developed a data collection tool in MS Excel. This spreadsheet included sections for each of the main study drivers as addressed by questions asked during the interview phase. The interview notes were analyzed to identify qualitative data that directly addressed the study drivers and were collected in individual cells in the spreadsheet. The spreadsheet additionally coded these data by company and investment phase. A representative portion of the spreadsheet is shown in figure 3.

Venture Capital Study Data															
Data Identification		Selection of Investments: How do you identify companies? What makes them attractive?				Government Funding: Positive or Negative?				Post-Investment Support: What do you do for portfolio companies?				Collaboration with NASA: How to	
Row ID	Stage	Theme	Quote	Theme ID Mapping	Positive	Theme	Quote	Theme ID Mapping	Theme	Quote	Theme ID Mapping	Theme	Quote	Theme	Quote
SF-11	Early														
SVC-01	Early	Avoid crowded markets	We avoid launch like the plague, it's too crowded.		Pos	Government and commercial mix	We want to hear from entrepreneurs that they can use this [gov contracts] to start, but I need to see that there's a commercial/government mix and how they will get there.		Final partnerships	We have one that does want to get their unit costs down so they're looking for partners, who can help with that.		Collaboration on tooling	We also discussed with them internally to say with a public-private part take? What are probably occur so I can do plans something that internally we know working with O like that would be useful.		
SVC-02	Early	Avoid single customer	We avoid anything that is beyond LEO because there is no customer base beyond NASA.		Neg	Risk in sole customer	Some companies have this problem, whoever pay the bills is the customer and you bend over backwards to please that one customer. This is a risk with government contracts.		Employee recruitment	It's a challenge we do a lot of sourcing employees, leadership, do market analysis, and find possible new product lines.		Market messaging for NASA	Is there anything that you the market place that is are some things that NASA listens because it's NASA. We can message.		
SVC-03	Early	Dual use products	In terrestrial/space dual use, it's because the space portion is strategic to future capabilities, and the terrestrial market keeps the company alive and profitable. A lot of it has to do with making sure the customer exists.		Pos	Provides economic stability	Now, the pandemic is a perfect example, if you have SBIR or government contracts and it keeps paying you'll come out able to take advantage of opportunities that others can't.		Leadership	It's a challenge we do a lot of sourcing employees, leadership, do market analysis, and find possible new product lines.		Market messaging by NASA	Is there anything that you the market place that is are some things that NASA listens because it's NASA. We can message.		
SVC-04	Early	Customer base	Have you discovered a problem that is so bad that someone is willing to give you a lot of money to solve it.						Market analysis	It's a challenge we do a lot of sourcing employees, leadership, do market analysis, and find possible new product lines.		Help on Artemis messaging	In the interest of working things you want people CLPS. We're more than that and DoD are really the sector.		
SVC-05	Early								New product lines	It's a challenge we do a lot of sourcing employees, leadership, do		Help on CLPS messaging	In the interest of working things you want people		

Figure 3. Data Analysis Findings Spreadsheet

The encoded qualitative data was analyzed to identify common themes as well as themes most directly related to the drivers of the study. A separate spreadsheet was created for each driver to collect these themes and allow the study team to analyze them by driver.

Once themes were compiled by driver, the study team met to analyze each theme and identify the study findings of most importance to advancing the goals of this study. These findings were further developed into recommendations and a path forward for NASA. The recommendations were reviewed with NASA's Office of the General Counsel, the Office of International and Interagency Relations, the Partnership Office, and with the Office of Procurement for feedback and to ensure compliance with federal regulations. Final recommendations are further discussed in the recommendations section of this report.

Findings and Themes from VC Interviews

Interviews with VC firms provided insight into how they make decisions, support their portfolio companies, work with partners, and how they would like to work with NASA. Major findings that support the recommendations of this team are grouped by project driver and described below.

To learn how VCs make investment decisions, and how NASA could adopt their methodologies to evaluate R&T proposals

The "Team" is one of the most important aspects of a startup

Early stage investment, as related by several VC firms, is a high-risk, high-reward endeavor. VCs look very carefully at the startup "team", with criteria such as:

- Does the team have previous experience?
- Does the team cover all of the required areas of expertise?
- Has the leadership of the team established a good culture that understands importance of diverse thoughts and opinions?
- How strong is the team's commitment to the success of the company?
- Does the team appear resilient enough to overcome adversity?
- Does the team have a plan to determine when it needs to pivot?
- What outside support can they leverage to help their team?

Most VC firms noted that the makeup and experiences of the original founders and team is one of the key, if not the most important, factors in selecting companies in which they invest.

Dual-use technologies and commercial products reach a larger set of potential suppliers and customers

Dual-use technologies, that benefit commercial as well as government customer needs, open the market potential of the technology. VCs consider this aspect particularly important for technologies of interest to the government. Several VCs that we spoke with consider the government an excellent customer for providing sustained investment, particularly through chaotic market moments. In contrast, other VCs indicated that working with the government requires significant time and effort that often discourages exploring dual use applications and that the government alone is unlikely to produce the billion dollar market that VCs hope to attract.

To better understand the ongoing support that VCs provide to the Entrepreneurs that receive VC investment

VCs encourage their portfolio companies to support one another, providing one another with a community that is going through the same processes

Many VCs treat the collective group of startups that they invest in for a given round as a "cohort", and encourage them to interact through frank, informal discussions as part of their normal activities. This allows startups to share problems and solutions and to support each other. VCs also hold periodic, facilitated discussions with the cohort to share insights on market trends, offer advice, and provide opportunities to field and answer questions.

VCs support and speed the development of their startups

For most VCs, startups are engaged directly into a special program designed by the VC to accelerate their development and reduce the time to market. Examples include “Masters Classes” conducted by a general partner, business development workshops, interactions with potential customers, and accelerator programs. VCs will also help their portfolio companies find their next level of funding and have personal accountability to help them progress to a successful business. VCs frequently take board seats or board observer seats to help make strategic decisions for the company and may also find any missing talent that a startup team requires to help reduce their execution risk.

VCs provide networking opportunities for their startups

VCs facilitate networking opportunities for their portfolio companies to meet with peers, collaborators, and potential future customers. A lot of networking and insight can be gained at technical conferences and trade shows, even virtually.

The timelines and documentation needed for contracting with the government are often difficult for startups to support

VCs indicated that startups are intimidated by the prospects of working with the federal government. Many startups contain only a handful of people and typically do not understand the federal acquisition regulations (FAR) and government contracting. If the VC sees that the federal government is an important potential customer to provide sustained funding for a company they often provide support services to work with these companies and help them understand the government contracting process. However, due to the time, cost, and organization required it is key that the government be one of many customers for the proposed product and not the only customer.

To explore how NASA could leverage VC's investment funding to develop and mature technologies that NASA needs

VC firms would like to better understand NASA needs

VC firms expressed an interest in working with NASA but several mentioned that first they need to understand NASA's needs. However, these needs should be expressed more as capabilities rather than specific requirements. Understanding these needs would allow VCs to work with NASA on understanding the technologies, startups, and markets that best meet those needs.

To explore how we might engage with VCs to further commercialize and spinoff mature NASA technologies

Sharing technical insights with the VC community would help inform their understanding for investing in commercial markets of interest to NASA.

Space is a difficult business, and the companies that are trying to enter that market need investors that understand the unique aspects of space commerce. As an example, several VCs indicated that the investment community knows little to nothing about in-space manufacturing, a key capability to support LEO commercialization. NASA has a lot of new information on this and related topics to share with this community to help support investment decisions that can meet requirements for both VCs and NASA.

Recommendations

The study team developed 12 recommendations, and proposed initial go-forward implementation plans, for NASA based on the research findings of this study. The recommendations address five different value propositions to the Agency.

Value Proposition: Assess and equip NASA teams for greater success

Recommendation 1: Assess the proposed internal project team when evaluating NASA's R&T Program proposals

Context: VCs spend a lot of time understanding the “Team” involved in a startup when considering investment; that is, the key personnel (CEO, CTO, etc.) of the company. Do they have the right experience, are they coachable, have they been successful in the past, do they demonstrate commitment, how well can they handle adversity, etc.

Most successful startup teams ‘pivot’, or significantly adjust their plans to match new market insights, at least twice before achieving success. Planning for these pivots allows startups to overcome adversity and responding to lessons learned.

VCs are motivated by financial gain as they analyze the potential of the “Team” for long-term success. While not profit driven, NASA R&T programs have an analogous motivation to analyze the potential of a proposal “Team” for long-term success to infuse technology into an existing program or future mission.

While not all approaches used by VCs could be adopted by NASA, the VC Study team believes that NASA program executives should consider the project team (and their supporting organizations) when evaluating internal NASA program proposal calls.

Proposed Forward Plan: For NASA R&T programs, establish criteria for internal (i.e., open only to NASA civil servants and support contractors) proposal calls analogous to the ‘key personnel’ and the ‘relative experience and past performance’ criteria used in external solicitations. Communicate to NASA teams that failure is an option and successfully pivoting, replanning, and sharing lessons learned are encouraged. One potential option to gain insight on project team members, including individual skills and responsibilities, is to include an ‘interview’ or open discussion with the project team during the selection process. Brainstorm ideas with NASA stakeholders to pilot an approach in one of NASA’s many internal research and technology programs.

Recommendation 2: Provide a means to help NASA innovators learn from each other, and to gain perspective from stakeholders as they execute their projects.

Context: Many VCs treat the collective group of startups in a given investment round as a “cohort” and encourage them to interact as part of their normal activities. This allows startups to share problems and solutions, and to support each other with a spirit of camaraderie. The VC also mentors their startups through engagement activities such as periodic ‘Masters Classes’ with the cohort to share insights on market trends, offer advice, and provide opportunities to field and answer questions. This personal involvement of the VC helps to ensure the success of the startups.

Rather than creating competitive tension VCs encourage their cohort to share information with one another. From the VC's perspective, the startups in the cohort are all struggling to develop and keep their businesses viable, and have a lot of commonality in the challenges that they face. They share their lessons on surviving in the environment, without sharing their unique intellectual property (IP).

The VC Study team suggests that NASA can apply an analogous approach and actively mentor internal project teams within NASA that are developing technology, to help them successfully create, mature, and infuse their innovations. Most startups seeking VC investment have a lot of “technical smarts” related to their particular intellectual property, but have less experience in developing a viable business. The VC Study team sees a parallel in the internal NASA R&T community – there are many brilliant innovators developing new technologies, but there is little experience or awareness of how to mature and infuse the technology into NASA programs.

The VC Study team believes that mentoring the innovators through the R&T maturation cycle from idea to infusion would increase both the likelihood of success and the impact of NASA's R&T investments. The study team also suggests project teams periodically touch base informally to share perspectives on the execution of their projects. NASA could use this approach in working with a set of projects that start in a given fiscal year.

Proposed Forward Plan: Work with one or more NASA R&T program executives to discuss piloting a cohort approach for internal NASA R&T projects, where teams can help each other succeed through R&T development, and program executives and selected subject matter experts could provide insight on topics related to technology infusion such as flight opportunities, commercialization, and technology transfer.

Recommendation 3: Increase stakeholder's engagement and direct support for NASA researchers to mature technologies through the various R&T Programs

Context Part 1: VCs help their invested companies find their next level of funding, and are personally accountable for helping investments grow into successful businesses. Within NASA, there are several programs that are needed to collectively mature and infuse a technology – there are over 30 R&T programs across the NASA mission directorates. For example, an internal idea from a NASA innovator could start as an Early Career Initiative project, then mature through a larger Game Changing Development project, followed by a Flight Opportunity Program effort, and then moved over to an Advanced Exploration Systems mission-specific prototype. The various program executives and stakeholders typically do not compare notes or discuss successful projects for consideration into the next step for maturation. The study team suggests increasing this internal dialogue, including engagement with the innovators.

Proposed Forward Plan - Part 1: NASA could emulate this idea with a “handoff review”, facilitated by the investing program executive, to help a successful NASA R&T project engage with the next R&T program to mature the technology. Alternatively, NASA could adapt the multi-stage SBIR “portfolio management” model to other NASA R&T programs. In this model completing an initial set of milestones can result in a project extension or additional funding; the final step of a Phase 1 SBIR project is to develop the proposal for an upcoming Phase 2 solicitation.

Context Part 2: VCs also find any missing talent that a startup team needs to help reduce their execution risk. Currently, a NASA program executive is typically constrained to accept a proposal “as is” during a proposal call. A highly impactful technology idea may not get selected for funding because of something lacking in the overall approach. If NASA adapts the concept from VCs to augment a startup team, it could similarly give flexibility for the program executive to augment the internal project being proposed to ensure both the impact and success of R&T efforts.

Proposed Forward Plan - Part 2: For internal program calls, caucus with program executives to discuss the idea of giving the program executives and other stakeholders the leeway to fund, augment, or add talent to a project team that they are investing in (e.g. systems engineering).

Value Proposition: Decrease the cost of NASA missions, increase innovation, and sustainability

Recommendation 4: Increase consideration within NASA of technologies and commercial products with multiple civilian uses, during program development and execution, to reach a larger set of potential suppliers to meet NASA needs.

Context: In many programs and projects, NASA makes the effort during formulation to perform market research and then create a “make vs buy vs partner” product breakdown structure to match system needs and architecture. This constrains individual component requirements and their interactions with each other until the end of the project. NASA’s formulation approach can disqualify a commercial product from use and often requires heavily engineered solutions to meet the overall system requirements if an optimal product breakdown structure is not identified.

VCs expressed a sentiment that products exist in various technical areas that could meet 70-80% of the requirements for 20-30% of the projected cost. Maintaining insight into available products and services throughout the program life-cycle can give tremendous flexibility to NASA programs in their decision making, affording the ability to ‘spin in’ products and services developed for another market, and narrow the set of needs that require custom, unique solutions and/or highly specialized product development. Unique requirements that are not common in the marketplace can discourage competition, especially with new businesses. In addition, many of NASA’s collaborative, no-exchange-of-funds partnerships involve use of agreements that match NASA’s needs with those of partners to accomplish Agency missions.

The VC Study team suggests that programs and projects maintain awareness of market products and solutions to adapt their planning throughout the execution life cycle. The understanding of potential commercial solutions and new technologies can be an important, ongoing risk management mitigation strategy. The study team proposes being more flexible in individual component or technology options within an overall system. This would increase the potential for solutions to be used that have applicability to other markets, lower life-cycle costs, and keep commercial interest in maintaining and evolving the product. Relaxing a requirement in one aspect of the system, to incorporate a commercial product, may be well worth the cost of implementing the requirement in another part of the system.

Proposed Forward Plan: NASA’s key stakeholders and support organizations can caucus to create market research strategies that can provide insight on emerging products and technologies of interest to NASA in technical areas identified by NASA mission directorates. Also, discuss the concepts and approaches for using ‘continuous’ market research as an approach for risk management and program execution.

Recommendation 5: Solicit periodic insight on emerging technologies and startups to increase NASA's understanding of potential commercial solutions to address NASA needs.

Context: To inform future NASA acquisition and innovation activities, a best practice is to perform market research. Currently, this is often a burden on individual programs and projects. The VC Study team believes that NASA could benefit from Agency-wide market research of key technologies and needed capabilities that are identified by the mission directorates.

Market tools are available that share insights on VC firms and commercial markets. These services have annual subscription fees and provide a series of tailored financial reports. NASA could pursue licenses to one of these tools for insights into VC firms and markets. NASA could also pursue contracting for a report of emerging technologies related to identified needs in the aeronautics and space domains.

Alternatively, NASA can reach out to VC firms through a “Request for Information” on commercial market trends and emerging companies related to NASA aerospace needs. The VC Study team believes that there was enough interest shown by the VCs interviewed as part of this study that several would respond to an abbreviated RFI. To realize the benefit of updated market information, the data call should be timed to provide insights for acquisition forecasting and for the PPBE cycle.

Proposed Forward Plan: NASA’s key stakeholders and support organizations can caucus to develop strategies on how to setup an approach for Agency-wide market research. NASA could also reach out to other government agencies, to exchange any market insights on emerging companies and key technologies of mutual interest.

Value Proposition: Increase the pool of potential commercial providers and valuable partners

Recommendation 6: Provide the ability to share technical insights with entrepreneurs and the VC community, to foster their domain understanding for developing and investing in commercial markets of interest to NASA.

Context: VC firms identified a lack of external awareness of NASA's aeronautics and space environments in general. For years, space has been considered a niche market that heavily favors large aerospace corporations. Basic technical knowledge on items such as microgravity, radiation, human rating, and safety considerations are not well understood outside of NASA and its local support contractors.

The VC Study team believes that raising awareness and domain knowledge of the aerospace environment to startups and the VC community would increase the pool of innovators, and the economic interests working to address NASA needs, provided that the Agency is able to maintain equity. The study team believes that VCs and startups would welcome the opportunity to become better informed, and any efforts undertaken to provide them and the general public with basic information should also increase nationwide engagement and external advocacy for NASA.

Proposed Forward Plan: NASA’s key stakeholders and support organizations that engage with industry can caucus to identify broad strategies for sharing domain knowledge insights – perhaps along the guidelines of an “Industry Day”, or the annual “Innovation and Opportunity Forum” that is conducted by the SBIR Program. Some other options include: developing webinars, informational videos, web features, or a website repository that are open to the public, or engaging with an academic institution to develop a series of short informational lectures. Additionally, NASA could leverage the search functions across agency databases to provide relevant information to targeted external audiences.

Recommendation 7: Consider the means to provide periodic forums to share already developed, public NASA needs with VCs and external startups

Context: The VCs interviewed for this study collectively control a significant set of financial interests equal to several times the annual NASA budget, and most believed that they lacked the insights of the potential commercial space markets needed to participate in supporting NASA.

The VC Study team believes that this is an untapped opportunity. To increase the potential for U.S. businesses to pursue aerospace opportunities, NASA would be well served to better identify and explain their needs and programs. The Agency engages with the public every day. There is a tremendously broad set of publicly available and released information on NASA programs and future needs, such as conference presentations, outreach briefings, and public engagement sessions that could be drawn from and shared. There are also existing industry engagement forums such as the National Science Foundation’s Space Technology Industry-Government-University Roundtable (STIGUR), sponsored by NASA, that could be expanded to enable dialogue on NASA needs. From the VC Study team’s perspective, it appears to be a small step beyond posting publicly released briefings and other information on a variety of websites and portals that could facilitate additional interest. (Ongoing procurement or embargoed data would not be included.)

Proposed Forward Plan: NASA’s key stakeholders and support organizations that engage with the public can caucus to develop a strategy to collect, organize, and share externally released and readily accessible information. Consider various approaches for engagement - perhaps starting with a “lecture series” pilot or an “Industry Day” type of activity, or leveraging the annual “Innovation and Opportunity Forum” that is conducted by the SBIR Program. Considerations would need to be made to ensure fairness and the opportunity for anyone interested to engage.

Recommendation 8: Raise awareness of the industry assistance services established by the Office of Procurement, and the OSBP, that provide help for startups seeking to work with NASA

Context: The VCs interviewed for this study believe that startups are intimidated by the prospects of working with the federal government. Many startups contain only a handful of people and typically do not understand the intricacies of the FAR and government contracting requirements, or the grants and other transactional authorities used by NASA.

Proposed Forward Plan: NASA's key stakeholders and support organizations can caucus to raise awareness of the existing industry assistance services available for startups. NASA could consider providing or expanding a liaison service to help startups navigate through tutorials and program websites in order to be prepared to respond to NASA solicitations. Where it differs from NASA's program, engage with the Department of Defense to better understand the "Mentor-Protégé program" that DoD has established where an established contractor or entity mentors an inexperienced one.

Value Proposition: Increase innovation and sustainability through greater use of partnerships; decrease the cost of NASA missions

Recommendation 9: Raise awareness within NASA of the various contracting and funding mechanisms available for NASA to reach startups.

Context: VCs noted that timelines and documentation needed for doing business with the government are often difficult for startups to support, especially in meeting performance-based specifications.

The VC Study team believes that NASA has acquisition programs and activities in place that are not fully leveraged. The study team understands that in Broad Agency Announcement (BAA) and SBIR type procurements, offerors have the ability to propose their own "statement of work" in response to a solicitation that is issued by NASA. This type of procurement seems to resonate well with startups, who can leverage previously developed technical documentation and business plans needed to receive financing. Research grants and cooperative agreements also serve NASA mission needs. Engaging with industry using NASA non-procurement partnership agreements offers both partners and NASA another available means to collaborate.

The study team believes that the strategies on when and how to engage these methodologies is not well understood within NASA, which may not be taking advantage of all available flexibilities. To engage with small businesses and startups, the VC Study team encourages use of acquisition methods that more readily facilitate commercial use and startups' participation in future NASA solicitations, if and where applicable.

Proposed Forward Plan: NASA’s key stakeholders and support organizations that engage with industry can caucus to share the various options available to program and projects, either through a “roadshow” or training session for NASA decision makers. Include insights on space act agreements and grants, as well as insight on how to commercialize technologies. Another suggestion is to create a focused training course that gives an overview of NASA small business engagement policy and strategies. Engage with NASA leadership to develop strategies to incentivize programs and projects to consider leveraging startups, balancing risk and reward.

Recommendation 10: Increase the ability for NASA researchers to participate in networking sessions to build insights, future partnering, and learn about related work in their field.

Context: VCs facilitate networking opportunities for their portfolio companies to meet with peers, collaborators, and potential future customers. Networking and insights can be gained at technical conferences, trade shows, and cross-industry communities of interest, even virtually.

NASA is encouraged to collaborate, to the point that many internal proposal calls identify a requirement for a NASA innovator to work with industry or another NASA center, and some NASA external calls require industry or academia to partner with NASA. NASA innovators need to maintain awareness of the current state of the art when planning new research or technology development, and can learn about new breakthroughs and recent successes through peer dialogue and technical discussions with the wider, external innovation community.

The VC Study team believes that NASA needs to carefully consider ideas to increase the effectiveness of collaboration.

Research is a peer-driven effort, and the VC Study team believes that some existing restrictions that impact networking (e.g., conference attendance, travel funding), also affect the ability of innovators to conduct and lead nationally recognized research.

Proposed Forward Plan: Caucus with NASA program executives and key stakeholders for ideas on to expand NASA’s collaboration network. For example, R&T programs that fund research and technology development can consider including the costs within future proposal calls for researchers to present and/or actively participate in a related technical conference or symposium as part of project closeout.

Value Proposition: Increase innovation and decrease the cost of NASA missions through knowledge sharing

Recommendation 11: Increase awareness of the engagement initiatives already being undertaken by NASA in working with startups and VCs.

Context: This study afforded team members from the different mission directorates to learn about some of NASA's internal VC engagement activities. Each of these efforts has lessons learned and best practices that could be applied to other NASA endeavors. Several initiatives, utilizing different approaches, are already in place. See Appendix B for a summary of these VC engagement activities.

Proposed Forward Plan: Facilitate periodic information sessions across NASA to share insights of ongoing industry engagement work at the field centers and at NASA HQ. NASA should disseminate and acknowledge the good work and engagement being done by Office of Small Business Programs (OSBP); Procurement; Space Technology Mission Directorate programs such as Tech Transfer and SBIR/STTR; Human Exploration and Operations Mission Directorate (HEOMD) activities such as the NextSTEP Broad Area Announcements (BAAs), and the Commercial Crew/Cargo programs; the NASA Aeronautics Research Institute within ARMD; and offices across NASA. Additionally, NASA can host an annual knowledge-sharing workshop as an overall innovation focused activity, where subject matter experts can share their insights.

Recommendation 12: Develop additional ideas from across the Agency on how NASA could encourage space commerce and technology infusion.

Context: Many innovations have come from the grass roots level, and VCs are open to, and often seek out, new ideas and perspectives that disrupt the status quo. This is a critical time for the Agency, with many simultaneously challenging goals across NASA's portfolio of work. Innovation will be a key component of NASA's future, and the OCT is helping to foster innovation across four themes: people, partnerships, portfolio and practices. As examples of innovative practices, NASA HEOMD is opening up the ISS to support LEO commercialization, and the Human Lander System program is providing civil-servant expertise to the contractor teams working to design lunar landers.

Proposed Forward Plan: Facilitate dialogue across the NASA workforce to identify needs and approaches to encourage innovation to meet NASA goals. One option is to hold an "Ideas to Value (I2V)" innovation event that could be used to collect and discuss ideas on how NASA could encourage space commerce and technology infusion. A potential question to consider: "How can NASA develop a market shaping and technology transition platform collectively?"

Conclusions

NASA has several past and current examples of working with venture capital firms. The tremendous power of the American economy has been a cornerstone of the Nation since its founding, and NASA's efforts and success are enabled by industry. The VC firms that the study team spoke with believe that the aerospace market is growing and that there are emerging commercial opportunities that new companies can pursue.

The timing of this VC Study is fortuitous. NASA is currently facing several simultaneous exploration, mission, and capability challenges across its mission directorates. Meeting these collective goals, to serve, and inspire the Nation, will require leveraging the very best that the Nation has to offer, including tapping into the entrepreneurial spirit that drives U.S. economic competitiveness.

From the findings of the OCT's recent "Barriers to Innovation" study, some areas that NASA is focusing on are: 1) to improve internal and external technology scouting; 2) to stay aware of external technology development; and 3) to consider flexibility in future partnerships. VCs are a potential partner to help address all of these focus areas. They are in the business of scouting for startups to invest in and have a strong motivation to thoroughly research potential companies and perform due diligence to identify startups that may have commercial success. Receiving some of this external insight from VCs would be valuable information for NASA decision makers.

Within NASA, OCT champions four pillars of innovation to ensure the Agency's continued success: Innovative people, innovative partnerships, innovative portfolio, and innovative practices. The venture capital community also engages in these four aspects of innovation as they relate to private investment.

- People: VCs encourage and develop innovative entrepreneurs through mentoring, networking, and the development of business plans.
- Partnerships: VCs leverage a broad spectrum of investors, subject matter experts and industry stakeholders to help guide startups to establishing a successful business venture.
- Portfolio: VCs analyze markets to identify unmet needs, carefully consider new ideas to support their portfolio companies, and work tirelessly to find market opportunities for them.
- Practices: Successful VC firms foster a culture that enables growth and collaboration through engagement, networking, and sustained commitment.

A VC balances their time between supporting current investments, maintaining awareness of market dynamics, and considering new investment opportunities. In addition to financial backing, venture capital firms provide a variety of support services to their portfolio companies. The VC Study team believes that the mentoring, guidance, team building, and networking aspects of a VC could be readily adopted within NASA for its own internal R&T programs, as indicated in some of this report's findings.

A venture capitalist invests in a team more than they invest in a product. A typical VC thoroughly engages and asks questions prior to investing. VCs are evaluating the character and personality of the key personnel. The interaction with the startup team is as important as the paperwork.

Several of the VC firms interviewed for this study are beginning to look at space as an emerging and viable market, but they lack the information on Agency needs and the various ways to engage with NASA opportunities. With additional understanding, the study team believes that a greater number of VCs would be confident investing in companies that could eventually provide products and services to help NASA.

Each of the VC firms interviewed for this study showed interest in learning more about NASA opportunities, and most offered to follow up in future dialogue to discuss potential strategies that NASA decides to pursue concerning VC engagement. NASA should be able to readily leverage this interest to engage in broad discussions with interested VC firms, and the network of startups that they represent, to provide information about future NASA needs and opportunities.

From interactions with venture capital firms, VCs appear to be very willing to provide insight and advice for how NASA technologies could have a greater impact in the marketplace and what may be needed to make the technologies more commercially viable. The VC Study team believes that NASA would be well served to formulate a time-efficient method to gain market perspectives from the VC network contacted as part of this study.

Several NASA initiatives, including STMD's iTech Program and both the NARI and Convergent Aeronautics Solutions efforts within ARMD, hold showcases periodically for new technologies and bring in VCs so they can meet with the teams and discuss potential investments. These activities leverage NASA's worldwide brand recognition and influence, resonate well with the external investment community, and are worth consideration by other NASA programs.

NASA's recent experience during the COVID-19 pandemic increases the potential for geographically dispersed project teams. The success of these kinds of dispersed teams could be applied to innovative project teams as well. During the course of the VC Study, the team discussed a potential model where a program executive or mission directorate leader located at NASA headquarters could assign a subject matter expert to work with a team of innovators at one of the Centers to help mature their technology. This allows the team to innovate their technology locally with expert support and leadership from headquarters.

Learning from the Nation's top investors and innovators can help NASA to address its top challenges, commercialization opportunities, and long-range needs and goals. Several programs across the Agency are already adopting agile and entrepreneurial methods for technology development that more closely match the early-stage business models of the private sector. From this research study, the VC Study team has suggested a dozen potential actions that could be undertaken now to leverage these lessons and a growing public interest in aeronautics and space.

Appendix A. Overview of Participating VC Firms

Organization	Profile
500 Startups San Francisco, California	Founded in 2010, 500 Startups provides seed capital and seed accelerator programs to companies worldwide in a range of industries, with a strong focus on software-related startups. 500 Startups has over \$454M in committed capital, with investments in over 2,400 companies spanning over 75 countries.
Accel Palo Alto, California	Founded in 1983, Accel is an early and growth-stage global venture capital firm that invests in technology companies across sectors, particularly enterprise software, consumer technology, and Fintech. Accel is one of the largest VC firms with a presence in Europe. As of March 2019, Accel has \$3B under management. Accel has made 1,396 investments, with 525 lead investments
Center for Innovation Technology Herndon, Virginia	Founded in 1985, the Center for Innovative Technology (CIT) is a nonprofit corporation that accelerates technology and technology companies in the Commonwealth of Virginia. CIT focuses on the early seed and commercialization stages, helping companies launch and grow, thereby contributing to the economic growth of Virginia. Two of CIT's major funding programs, the CIT GAP Funds and the Commonwealth Research Commercialization Fund, have invested \$28.8M and \$28M in companies and technologies, respectively
Goldman Sachs New York, New York	Founded in 1869, New York-based Goldman Sachs is a leading global investment banking, securities, and investment management firm. Goldman Sachs makes investments at debt, early stage venture, late stage venture, private equity, and seed stages. Goldman Sachs has \$198B in assets under management across 747 investments, including 303 lead investments
In-Q-Tel Arlington, Virginia	In-Q-Tel (IQT) is a not-for-profit strategic investing firm that connects the United States government, particularly the Central Intelligence Agency and the broader intelligence community, with startups to address national security needs. In-Q-Tel acts as a bridge between technology needs in the government with startups and their associated venture capitalists. The firm evaluates about 1000 companies per year and makes average investments of \$0.5M - \$3M
Insight Partners New York, New York	Founded in 1995, New York-based Insight Partners is a scale-up firm that invests in software companies. Insight Partners makes investments at debt, early stage venture, late stage venture, private equity, and seed stages. Insight currently has over \$20B of assets under management and has made over 400 investments, including 300 primary investments, 200 portfolio acquisitions, and 40 IPOs
Khosla Ventures Menlo Park, California	Founded in 2004, by Vinod Khosla (co-founder of Sun Microsystems), Khosla Ventures is a venture capital firm based in Menlo Park, CA. The firm invests in technology-based companies, from seed through late stages of growth across a range of industries. Khosla Ventures seeks to

Organization	Profile
	disrupt industries with new technology solutions and builds companies through mentorship and partnership with technologists. The firm has invested over \$19B in funds from early to late stage rounds
Plug and Play Tech Center Sunnyvale, California	Founded in 2006, California-based Plug and Play is a seed and early-stage investor focused on emerging growth companies across industries including mobility, health, energy, cybersecurity, supply chain, and more. Plug and Play offers industry-specific accelerator programs that act as a platform for major corporations and startups to connect and collaborate. Plug and Play has made 985 investments, including 44 lead investments
Quake Capital Partners New York, New York	Founded in 2017, New York-based Quake Capital Partners makes seed level investments in new and early stage ventures across a wide range of industries. Quake Capital offers an accelerator program and invests around \$150,000 in exchange for around 5-10% equity. Quake Capital has made 130 investments, including 63 primary investments
Revolution LLC Washington D.C.	Founded in 2005 and based in Washington D.C., Revolution makes early stage venture, late stage venture, and seed investments in innovative companies. Revolution invests across sectors, including education, financial services, entertainment, software, transportation, health, food, and more. Revolution has invested nearly \$2B across 123 investments, with 43 lead investments.
Space Angels/ Space Capital New York, New York	Founded in 2007 and based in New York, Space Angels manages early stage angel investments in entrepreneurial commercial space companies. Space Angels has been recognized as the leading space venture capital firm. Space Angels thoroughly vets their investments, selecting only the top 5% of space opportunities. Space Angels manages \$30M. Between 2015-2018, Space Angels made 37 investments in 26 portfolio companies, with 6 lead investments.
Space Fund Houston, Texas	Founded in 2018 and headquartered in Houston, Texas, SpaceFund is a tokenized venture capital firm investing in high-growth startups in the space industry. SpaceFund was created to change the way investments are made in this industry, with the goal of a decentralized approach to bring investment abilities to the masses. The firm is run by leaders in the space and blockchain industries who break the industry down into five major sectors: transportation, communication, human factors, supply chain, and energy. SpaceFund accomplished the first round of investments in its SpaceFund One portfolio, raising \$10M in 2019 through a security token offering with a 50M token supply
Starbridge Venture Capital New York, New York	Founded in 2017 in New York, Starbridge Venture Capital invests in dual-use technologies that serve both the commercial space economy and existing Earth-based industries. Starbridge focuses on early stage space technology startups that can create spinoff technologies to impact other terrestrial markets of interest. Since its founding, Starbridge has invested in at least nine companies, including Made In Space, Umbra Lab, and a \$16M seed investment in Axiom Space

Appendix B. Summary of Current and Previous NASA Workings with VCs

This study does not represent NASA's only collaboration with the venture capital community. As a first phase of this work, the study team spoke to NASA leaders who have previously worked on initiatives with VCs, including:



"Red Planet Capital" Initiative

The "Red Planet Capital" initiative was established in 2006, born from recommendations for building a robust space industry contained in the Aldridge Report that followed the Columbia accident. RPC was intended to serve as a strategic investment entity for NASA. The main goal of RPC was to enable a "window" to access cutting-edge technologies of interest to NASA that could influence future missions, from a wide breadth of private sector innovators. The RPC model contained three entities: NASA, a non-profit to facilitate the transferring of funding, and Red Planet Capital. Although envisioned as a multi-year program, with \$75 million of NASA funding planned over five years, RPC made one investment, in an anti-gravity treadmill company named ZeroG. RPC ceased operations in 2007 when the Office of Management and Budget gave guidance that this government-run venture fund would not receive funding in subsequent fiscal years. Lessons from the Red Planet Capital activity were incorporated into this study.



JPL Innovation Foundry

JPL Innovation Foundry Website: <https://jplfoundry.jpl.nasa.gov/>

The Innovation Foundry at NASA's Jet Propulsion Laboratory (JPL) coordinates and provides leadership for all JPL activities associated with the development and capture of business opportunities. Working in partnership with JPL's program directorates, the Foundry facilitates and guides advanced studies, concept development, and proposal support to JPL personnel for innovative project formulation. The Foundry works with internal and external JPL partners to bring their space mission ideas from the initial concept to a complete proposal package, including targeting an opportunity for flight. A primary focus of the Innovation Foundry is to leverage cubesats and smallsats to develop and mature science technologies which can be infused for upcoming NASA science missions. One recent example technology is diamond-packed gallium arsenide amplifiers which expanded CubeSat communication capabilities. The JPL Innovation Foundry emulates many of the rapid, agile product development practices employed by startups. Through the Innovation Foundry, JPL has established a special arrangement with the VC firm Starburst Accelerator to provide guidance to innovators on creating business and commercialization plans for JPL-developed technologies.



iTech Program

NASA iTech Website: www.nasaitech.org

The iTech Program was established to help understand disruptive technologies in technical fields that are of interest to NASA and to provide exposure for entrepreneurs to subject matter experts and venture capitalists to foster external investment. iTech is a "spin in" research and technology program within the Space Technology Mission Directorate; entrepreneurs develop a solution to meet a commercial market need, and iTech looks at potential applications of that same innovation to meet NASA's Aeronautics and Space needs. One recent success story is "GermFalcon²". A doctor adapted a method to sterilize hospital rooms into a service-cart sized module that could sterilize the cabin of an airplane within 15 minutes. With VC investment, GermFalcon is now a commercial product, being deployed at airports, and may help to contain the spread of the recent CoronaVirus pandemic, and there is interest within NASA to fly a space-qualified unit to sterilize the ISS or the Gateway. Through iTech, NASA does not own any of the intellectual property of the selected innovators, nor does NASA provide any investment funds. iTech provides a vetting and presentation forum for entrepreneurs to share their innovations to NASA technologists and stakeholders, and NASA selects innovations that are particularly noteworthy. Industry subject matter experts and venture capitalists that participate in the iTech sessions can then, completely separate from NASA, engage with the innovators and potentially invest in them..



SMD Entrepreneur Challenge

SMD Entrepreneur Challenge website:

[https://www.challenge.gov/challenge/nasa-entrepreneur-](https://www.challenge.gov/challenge/nasa-entrepreneur-challenge-2020/)

[challenge-2020/](https://www.challenge.gov/challenge/nasa-entrepreneur-challenge-2020/)

NASA's Science Mission Directorate conducted a pilot program—the Entrepreneurs Challenge (EC)—to support the development of new science instruments and related technologies that will advance the Agency's science exploration goals. SMD sought novel ideas from early-stage companies, specifically in areas of artificial intelligence, mass spectrometry, and quantum sensors. In round one of the competition, participants submitted proposals in these areas and NASA selected 15 businesses and start-ups to present their ideas in round 2—a Virtual Pitch Event on July 29, 2020.

During the Virtual Pitch Event each selected candidate presented their product to a panel of NASA judges. Venture capitalists also attended the event to learn about key SMD technology development needs and the methods that these start-ups were using to address current barriers to technical advancement. In addition, a panel of invited VC representatives led a discussion on "Investment Trends & State of the Market." Investors were also provided the opportunity to schedule time with the EC participants to meet privately. The event provided a novel forum for NASA technologists, venture capitalists, and disruptive startup companies to interact. Ten winners of the Virtual Pitch Event were awarded funding to continue their technology development. These winners

² website: <https://www.germfalcon.com/>

were also awarded follow-up coaching opportunities from the NASA SBIR program and SMD mentors to match their concepts with a NASA problem. During round 3, winners submit a white paper to detail their work on NASA problems and the application of their technology. The selections from round 3 will be awarded additional prize funding.

SMD recognizes the potential for valuable contributions from innovative entrepreneurs. However, the directorate also realizes that there are barriers that prevent such entities from participating in NASA's technology development programs and unleashing their full potential. Under this new initiative, SMD issued a prize/competition for entrepreneurs to "swing for the fences" and successfully identified several game-changing technologies that have the potential to advance the state-of-the-art and enable Agency objectives.



[Convergent Aeronautics Solutions Project](#)

CAS website: <http://www.nasa.gov/aeroresearch/programs/tacp/cas>

The Convergent Aeronautics Solutions (CAS) project invests in innovative ideas that could lead to solutions for the problems that plague and impact aviation safety, the environmental and community impacts of air travel, and the global growth in air traffic.

The goal of CAS is to rapidly assess the feasibility of novel concepts to determine if additional investment is warranted. Those that prove feasible are expected to transition into more focused technology development projects to mature and apply the enabling technologies. Concepts that are selected are given continued support under an agile "light management" approach that emphasizes outcomes over activity and reporting.

Past CAS investments have been made using a venture capital-inspired approach including an annual pitch competition which is used to select the next round of studies. Currently, the process CAS uses to select concepts for evaluation is under review and will be undergoing changes. The driver for change is two-fold. There is a desire to focus on key areas requiring innovation and increase the potential for transition of feasible ideas to industry and within NASA.



[NASA Aeronautics Research Institute](#)

NARI website: <https://nari.arc.nasa.gov/>

NASA Aeronautics Research Institute (NARI) operates at the nexus of industry, government and academia with an outward-facing approach to monitor trends and aviation needs. NARI's goal is to develop partnerships that maximize impact to meet future aviation demands and opportunities consistent with Aeronautics Research Mission Directorate strategic thrusts.



NASA Entrepreneurial Workforce Initiative

NEW Initiative website: <https://www.fedtech.io/>

The NASA Entrepreneurial Workforce Initiative was created by the Technology Transfer Program within STMD to help NASA employees learn about entrepreneurialism in a practical environment and to enable participants to gain perspective from industry while exploring potential commercial applications and partnership opportunities for NASA technologies. Managed out of NASA Headquarters, this experiential training program introduces an innovative approach to accelerate the introduction of new technologies into private industry and spur economic growth linked to NASA-funded research. There are three components within the Initiative. Commercialization Boot Camps provide innovators and stakeholders a 'crash course' on startups and a basic understanding of entrepreneurial and market concepts, as well as value proposition development. The follow-on Entrepreneurial Training Academy, a four week session for innovators with a potential market solution, helps identify commercial viability, licensing opportunities, investment readiness, and supports the development of a pitch deck. Lastly, the Startup Accelerator Program works with a business management consultant, FedTech, to provide insights into how to formulate, develop, and launch a business.



SBIR/STTR Program

NASA SBIR/STTR Website: <https://sbir.nasa.gov/>

The NASA Small Business Innovative Research (SBIR) and Small Business Technology Transfer (STTR) programs represent the primary means through which NASA invests in technology startups. Collectively, the programs stimulate high-tech innovation by funding the research, development, and demonstration of technologies that fulfill NASA needs and that have significant potential for successful commercialization. Through a competitive awards-based program, SBIR and STTR enable qualified small businesses to explore their technological potential and provide the incentive to profit from their commercialization. The SBIR Program is structured in three phases, with increasing levels of investment to help startups establish the technical merit, feasibility, and commercial potential of the proposed research and development efforts while at each phase assessing the performance of the small business awardee organization.

The SBIR/STTR Programs are extremely important efforts in meeting NASA's research and technology needs, and the Programs, and, through the recent "Venture Capital 101" lecture series, are actively leading change by raising the awareness of NASA innovators and stakeholders of the market dynamics that drive small business innovation.



Tech Transfer Program

NASA Tech Transfer Website: <https://technology.nasa.gov/>

NASA's Technology Transfer Program within the Space Technology Mission Directorate ensures that innovations developed for exploration and discovery are broadly available to the public, maximizing the benefit of the space program to the Nation. NASA develops a wealth of individual technologies to address the challenges of exploring space, understanding and monitoring the earth, and improving air transportation. Through a licensing process, a US commercial entity can draw upon over 1,200 NASA-developed technologies in the development of commercial products or services to benefit the public. NASA's Technology Transfer Portal maintains a searchable portfolio of patents, organized into fifteen technical focus areas, that covers a broad range of innovations. NASA's Tech Transfer Program works with American businesses to provide three types of technology licensing agreements: a Standard Commercial License, an Evaluation License, or a Startup License. Hundreds of US businesses have been enabled or supported by NASA's Tech Transfer Program, promoting economic opportunity across the United States.

Appendix C. Acknowledgments

The Venture Capital study team, representing all of the NASA mission directorates, gratefully acknowledges the contributions made by representatives of several venture capital firms, and by subject matter experts inside and outside of NASA. The candor, insight, and perspectives shared with the study team were enlightening, encouraging, and strongly influenced the findings and recommendations put forth in this report.

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